Determining an Empirical Formula

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An empirical formula is the smallest whole number ratio between the elements in a compound. For ionic compounds the empirical formula is the same as the chemical formula, also known as the formula unit. However, in molecular compounds the chemical formula is often different from the empirical formula.

	Chemical Formula	Empirical Formula
ethane	C_2H_6	CH_3
ethyne	C_2H_2	CH
water	H_2O	H_2O
sodium chloride	$NaCl$	$NaCl$
glucose	$C_6H_{12}O_6$	CH_2O

To determine an empirical formula you must have the percentage composition of the compound.

We start by assuming there is 100g of the compound. We then find the mass of each element in the 100g of compound using the percentage composition. Then the masses of each element are converted into moles of each element. Finally the ratio of the moles is put into lowest whole numbers.

Example #1: Determine the empirical formula of a compound with a percentage composition of 38.71% carbon, 9.71% hydrogen, and 51.58% oxygen.

Solution:

Assume there is 100 g of the compound.

$m_C = 38.71\% \times 100\,g = 38.71\,g$

$m_H = 9.71\% \times 100\,g = 9.71\,g$

$m_O = 51.58\% \times 100\,g = 51.58\,g$

$$n_C = 38.71\ g \times \frac{1\ mol}{12.01\ g} = 3.223\ mol$$

$$n_H = 9.71\ g \times \frac{1\ mol}{1.01\ g} = 9.614\ mol$$

$$n_O = 51.58\ g \times \frac{1\ mol}{16.00\ g} = 3.224\ mol$$

$\therefore$ the empirical formula is $C_{\frac{3.22}{3.22}} H_{\frac{9.61}{3.22}} O_{\frac{3.22}{3.22}}$

$\therefore$ the empirical formula is CH_3O.

Example #2: What is the empirical formula for a compound that has a percentage composition of 69.9 % iron and 30.1% oxygen.

Solution:

Assume there is 100 g of compound.

$m_{Fe} = 69.9\% \times 100\,g = 69.9\,g$

$m_O = 30.1\% \times 100\,g = 30.1\,g.$

$n_{Fe} = 69.9\,g \times \frac{1\,mol}{55.85\,g} = 1.252\,mol.$

$n_O = 30.1\,g \times \frac{1\,mol}{16.00\,g} = 1.881\,mol.$

Fe	:	O
$\frac{1.25}{1.25}$	:	$\frac{1.88}{1.25}$
1	:	1.5
2	:	3

∴ the empirical formula is Fe_2O_3

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